REMARKS

This Preliminary Amendment cancels, without prejudice, claims 1 to 12 in the underlying PCT Application No. PCT/EP2003/013265 and adds new claims 13 to 28. The new claims, inter alia, conform the claims to United States Patent and Trademark Office rules and does not add any new matter to the application.

In accordance with 37 C.F.R. § 1.125(b), the Substitute Specification (including the Abstract) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to United States Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. §§ 1.121(b)(3)(ii) and 1.125(c), a Marked-Up Version of the Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

The underlying PCT Application No. PCT/EP2003/013265 includes an International Search Report, dated April 15, 2004, a copy of which is included. The Search Report includes a list of documents that were considered by the Examiner in the underlying PCT application.

The underlying PCT Application No. PCT/EP2003/013265 also includes an International Preliminary Examination Report, dated October 19, 2004. An English translation of the International Preliminary Examination Report and annex thereto are included herewith.

It is respectfully submitted that the subject matter of the present application is new, non-obvious and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully submitted,

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RACK-AND-PINION ELECTRO-STEERING SYSTEM

FIELD OF THE INVENTION

The present invention relates to a rack-and-pinion electro-steering system, ~~particularly~~ **e.g.,** for motor vehicles, having a rack extending in a housing, which is operatively connected to a thrust member/pinion pairing.

BACKGROUND INFORMATION

Rack-and-pinion electro-steering systems are operated by an electrical system instead of a hydraulic system. It is made up of an electric motor, a gear unit for power transmission as well as the control electronics and sensor system. The steering torque exercised by the driver is evaluated by the sensor system of the power steering and is converted into an electrical signal which is converted by the electric motor and the gear unit into a corresponding servo-torque and transmitted to the steering. ~~Known~~ **Conventional** rack-and-pinion electro-steering systems are steering column drives, pinion drives, double pinion drives as well as axially parallel drives.

In ~~the known~~ **conventional** rack-and-pinion electro-steering systems, the rack is thrust by one or two thrust members against a corresponding number of pinions so as to produce a good tooth-engagement between the pinion and the rack. In general, rack-and-pinion electro-steering systems have two pinions or pinion toothings, one pinion being connected to the servo-side, i.e., to the electric motor and the other pinion being connected to the sensor side or the steering column. For this purpose, the thrust members guide the rack and thrust it against the pinion toothing.

~~Disadvantageous is the fact that the~~ **The** rack-and-pinion electro-steering system can produce disturbing noises. One source of noise is the rack and another source of noise are the thrust members. The noise generation is especially high in rack-and-pinion electro-steering systems that have two thrust member/pinion pairings, due to the degrees of freedom at the rack and thrust members. The disturbing noise generation, however, occurs also in rack-and-pinion electro-steering systems that have merely one thrust member/pinion pairing. A cause of the noise generation is to be found in ~~the fact~~ that the different toothing forces on the sensor side and servo-side cause a tilting of the rack which results in a knocking of the steering system particularly in rapidly alternating steering.

~~In a disadvantageous manner, the~~ **The** tilting of the rack **may** also ~~results~~ **result** in a high degree of wear of the pinion toothing.

Irrespective of, or in addition to, the noise generation on account of the rack, undesired noises are also generated ~~by the fact that~~ **due to** the thrust members, which are embedded in a housing part, ~~have~~ **having** a tendency to tilt.

~~The known~~ **Conventional** thrust members are made from aluminum or generally from metal and have a sliding film at their concave contact surface facing the rack. Generally an O-ring is located between the thrust member and the surrounding housing part, which is to prevent dust from entering.

In this connection, [[DE]] **German Published Patent Application No.** 100 49 570 [[A1]] and the following documents ~~must be mentioned as related art~~ **should be referred to for additional background information**: [[DE]] **German Published Patent Application No.** 199 29 932 [[C2]], **German Published Patent**

Application No. [[DE]] 33 32 483 [[C2]], **German Published Patent Application No.** [[DE]] 694 12 701 [[T2]], **German Published Patent Application No.** [[DE]] 28 07 005 [[A1]] and **German Published Patent Application No.** [[DE]] 34 08 673 [[C2]].

SUMMARY

~~The~~ **An example embodiment of the** present invention ~~is based on the objective of creating~~ **may provide** a rack-and-pinion electro-steering system, which ~~solves~~ **may address** the above-mentioned disadvantages, preventing ~~in particular~~ **e.g.,** the occurrence of disturbing noises in a simple and cost-effective manner and minimizing the wear of the pinion toothing.

~~According to the present invention, this objective is achieved by the characterizing part of Claim 1.~~

~~Due to the fact that~~ **Since,** between the rack and the housing a bearing is provided for guiding the rack, the thrust members ~~now~~ **may** only have to absorb the toothing forces. Disturbing noises due to a tilting of rack ~~are~~ **may** thereby **be** prevented. Thus knocking ~~is~~ **may be** avoided even in rapidly alternating steering.

The bearing between the rack and the housing **may** also ~~minimizes~~ **minimize** the wear of the pinion toothing in a particularly advantageous manner. In ~~the design approaches known from the related art~~ **conventional systems**, the tilting of the rack ~~resulted~~ **may result** in a high degree of wear, which ~~is~~ **may be** minimized ~~now that~~ **since** the bearing prevents a tilting of the rack.

The use of a bearing between the rack and the housing surrounding the rack ~~is~~ **may be particularly** suited ~~in a particularly advantageous manner~~ for rack-and-pinion electro-

steering systems having two pinions which engage into the rack when thrust by the respective associated thrust member. For this purpose, one pinion is operatively connected to the servo-side of the electric motor and one pinion is operatively connected to the sensor side or to the steering column. ~~Irrespective of the fact that the design approach according to the present invention is particularly suited for this purpose, in~~ **In** rack-and-pinion electro-steering systems having only one thrust member/pinion pairing, as, e.g., in a steering column drive or in a pinion drive, a reduction of the wear in the pinion toothing ~~is~~ **may be** achieved as well due to the optimum guidance of the rack.

According to **an example embodiment of** the present invention, the bearing is ~~designed~~ **arranged** as a sliding bearing. ~~This is because experiments have shown that a~~ **A** construction of the bearing between the rack and the housing as a sliding bearing ~~is~~ **may be particularly** suited ~~particularly well~~ for a reliable, durable and cost-effective guidance of the rack in the housing.

In addition, for mounting the sliding bearings on the rack, a lock geometry is provided by which the sliding bearings may be locked after having been mounted on the rack. The lock geometry, for example, may be based on the lock geometry customary in sealing rings in automatic transmissions.

~~Advantageous embodiments of the present invention are derived from the subordinate claims:~~

~~Accordingly, two~~ **Two** sliding bearings may further be provided for guiding the rack in the housing.

~~As experiments have likewise shown, guiding~~ **Guiding** the rack in the housing using two sliding bearings **may** also ~~allows~~

allow for a particularly suitable guidance, which ~~eliminates~~ **may eliminate** a tilting of the rack and hence the occurrence of noises and a high wear of the pinion toothing.

~~A further development~~ **An example embodiment** of the present invention may additionally provide for the thrust member to be manufactured essentially from plastic, ~~preferably~~ **e.g.,** from a slide-modified high-performance plastic.

Due to the fact that the thrust member is essentially made of plastic, noises between the thrust member and the housing part surrounding the thrust member ~~are~~ **may be** minimized. ~~It is advantageous for this purpose if the~~ **The** thrust member ~~is~~ **may be** manufactured using injection molding technology from a slide-modified high-performance plastic such as Torlon 4301, which produces the same thermal linear expansion as the housing material used.

Movements of the thrust member generally ~~run~~ **extend** radially with respect to the rack and result from knocks or similar effects on the rack which are accordingly transmitted to the thrust member. ~~Due to the refinement~~ **By being** made from plastic or ~~in an advantageous manner~~**, e.g.,** from a slide-modified plastic, the thrust member ~~can~~ **may** readily move with respect to the housing part without causing disturbing noises[[.]] ~~A refinement of the thrust member made from plastic or from a high-performance plastic additionally allows~~ **and may allow** for an elimination of the O-ring ~~hitherto necessary~~ **previously required** in thrust members made of metal or aluminum, which is supposed to prevent dust, dirt ~~and the like~~**, etc.** from entering. The possible omission of the O-ring ~~eliminates~~ **may eliminate** another source of noise. Due to the minimal contact surface of the O-ring at the housing and its easy deformability, ~~hitherto known~~ **conventional** thrust members have tended to tilt around the O-ring. In that the O-ring is

~~now~~ eliminated **herein** and the thrust member is instead made from plastic, a tilting and the associated noises ~~are~~ **may be** prevented.

Moreover, the ~~hitherto~~ **previously** required sliding film, which the thrust member has on its concavely formed side facing the rack, may be omitted. This ~~simplifies~~ **may simplify** the handling in the installation of the thrust member since ~~now~~ only a single part needs to be installed. On the other hand, the manufacture of a thrust member from plastic ~~is~~ **may be** possible in a simple and cost-effective manner compared to the existing thrust members made of metal or aluminum.

~~Advantageous refinements and further developments of the present invention are derived from the additional dependent claims and from exemplary embodiment represented in the following with the aid of the drawing.~~

BRIEF DESCRIPTION OF THE DRAWING

~~The sole figure of the drawing shows~~ **Figure 1 illustrates** a rack-and-pinion electro-steering system having a housing, a rack extending in the housing as well as two thrust member/pinion pairings, which are operatively connected with the rack, the rack being guided in the housing by two sliding bearings.

DETAILED DESCRIPTION

~~Rack-and-pinion~~ **Certain rack-and-pinion** electro-steering systems are ~~sufficiently known from the general related art~~ **conventional** and are generally used as an alternative to a hydraulic system. Rack-and-pinion electro-steering systems essentially exist as pinion drives, as double pinion drives or as axially parallel drives. Depending on the ~~variant~~ **arrangement**, one or two pinions engage in the rack.

~~Since rack-and-pinion electro-steering systems are already sufficiently known from the general related art, in the following only the features essential for the present invention will be addressed in more detail.~~

~~The rack-and-pinion electro-steering systems according to the present invention, however, is not limited to this.~~

~~The exemplary embodiment shows~~ **Figure 1 illustrates** a section of a rack-and-pinion electro-steering system having a housing 1 and a rack 2 extending within it. Rack 2 is ~~here~~ operatively connected with two pinions 3a, 3b, each of which ~~have~~ **includes** one thrust member 4a, 4b assigned to it. ~~In a manner not shown, pinion~~ **Pinion** 3a is connected in the exemplary embodiment to a servo-side or an electric motor, while pinion 3b is connected to a sensor side or to a steering column ~~that is likewise not shown~~.

Between rack 2 and the cylindrical part 1c of housing 1 surrounding rack 2, two bearings in the form of sliding bearings 5 are ~~situated~~ **arranged**. Sliding bearings 5 are used for guiding rack 2 in housing 1, which means that this task no longer has to be assumed by thrust members 4a, 4b. Thrust members 4a, 4b therefore only have to absorb the toothing forces. ~~It is advantageous if housing~~ **Housing** 1, ~~particularly~~ **e.g.,** cylindrical housing part 1c, ~~is~~ **may be** honed throughout.

~~The exemplary embodiment provides for a~~ **A** plastic, ~~preferably~~ **e.g.,** a high-performance plastic suitable for high temperatures, ~~to~~ **may** be used as the material for manufacturing sliding bearings 5. High-performance plastics such as Solvay Torlon 4301 or DuPont Vespel SP211 ~~are~~ **may be** suited for this purpose ~~in a particularly preferred manner~~. A manufacture of sliding bearings 5 using injection molding technology ~~has proven to~~ **may** be particularly suitable. For mounting sliding

bearings 5 on rack 2, a lock geometry ~~is~~ **may be** provided ~~in the exemplary embodiment~~ by which sliding bearings 5 may be locked after having been mounted on rack 2. The lock geometry for example may be based on the lock geometry customary in sealing rings in automatic transmissions.

~~The exemplary embodiment provides for sliding~~ **Sliding** bearings 5 ~~to~~ **may** be ~~situated~~ **arranged** in each case as closely as possible in the region of pinion 3a or 3b since occurring noises may thus be additionally attenuated ~~in a particularly advantageous manner~~. Moreover, sliding bearings 5 are thus spaced particularly far apart from each other, which ~~provides~~ **may provide** for a particularly advantageous guidance of rack 2. If the possibility exists, sliding bearings 5 may also be inserted in cylindrical part 1c of housing 1 as an alternative to the arrangement of sliding bearings 5 on rack 2.

~~The exemplary embodiment provides for sliding~~ **Sliding** bearings 5 ~~to~~ **may** be ~~situated~~ **arranged** in a tooth-free region of rack 2 such that a contact with pinions 3a, 3b ~~is~~ **may be** precluded.

In order to suppress noise generation in the region of thrust members 4a, 4b, ~~the exemplary embodiment provides for~~ a sliding bearing or a sliding bushing 6 ~~to~~ **may** be used between thrust member 4a, 4b and housing part 1a, 1b surrounding thrust members 4a, 4b, which spans the contact region between the respective thrust member 4a, 4b and the surrounding housing part 1a, 1b. Thus a noise generation through the movement of thrust members 4a, 4b in relation to housing parts 1a, 1b ~~is~~ **may be** reduced or eliminated completely.

In ~~the hitherto known design approaches with respect to the related art~~ **conventional systems**, thrust member 4a, 4b made of metal or aluminum rubbed against the respective housing parts 1a, 1b, which on the one hand produced noises and on the other

hand resulted in a corresponding wear. Merely the use of an O-ring between the respective thrust member 4a, 4b and housing part 1a, 1b, which was to keep out dust ~~and the like~~ **etc.**, was ~~hitherto~~ **conventionally** provided ~~for~~. ~~In this connection, the inventors established that the~~ **Conventional** thrust members ~~known from the related art~~ **may** tilt about the O-ring and deform it, which results in the already mentioned noises and signs of wear. These noises are effectively prevented by using a sliding bushing 6 or a sliding bearing. As the exemplary embodiment reveals, sliding bushing 6 assigned to the respective thrust member 4a or 4b extends across the entire width of thrust member 4a or 4b.

Sliding bushing 6 ~~advantageously acts~~ **may act** as a sound buffer between the components as well as minimizing friction.

~~The exemplary embodiment provides for sliding~~ **Sliding** bushing 6 ~~to~~ **may** be essentially made from a plastic, ~~preferably~~ **e.g.,** a high-performance plastic. For this purpose, the same high-performance plastic may be used as in the already mentioned sliding bearings 5. A manufacture using injection molding technology ~~is~~ **may be** suitable ~~in a particularly advantageous manner for this purpose as well~~.

~~The exemplary embodiment shown provides for sliding~~ **Sliding** bushings 6 ~~to~~ **may** be inserted into housing part 1a, 1b.

As an alternative to sliding bearings 5 or sliding bearings 6, the use of ~~known~~ **conventional** bearings or bearing bushings ~~obvious to one skilled in the art is~~ **may be** possible as well.

~~A variant of the design approach according to the present invention, which is not shown, can provide for thrust~~ **Thrust** members 4a, 4b ~~to~~ **may** be manufactured essentially from plastic, ~~preferably~~ **e.g.,** from a high-performance plastic.

The high-performance plastic already described with respect to sliding bearings 5 ~~is~~ **may be** suitable for this purpose. ~~It is advantageous in this regard if the~~ **The** high-performance plastic ~~is~~ **may be** slide-modified as, e.g., Torlon 4301. ~~The advantage in this variant, in which~~ **Since** thrust members 4a, 4b are essentially made of plastic, ~~is that~~ both the O-ring required in ~~the existing related art~~ **conventional systems** as well as the sliding film facing rack 2 may be omitted. The required ability to slide ~~is~~ **may be** ensured by thrust member 4a, 4b due to the construction made of plastic. ~~In comparison to the exemplary embodiment, sliding~~ **Sliding** bushing 6 may also be omitted. A construction of thrust members 4a, 4b from plastic ~~makes~~ **may make** it possible that ~~now~~ only one single piece needs to be installed.

The design approach ~~according to the present invention~~ **hereof** is not only suitable for the rack-and-pinion electro-steering systems ~~shown in the exemplary embodiment~~. Rather, the design approach ~~according to the present invention fits~~ **hereof may fit** all ~~known~~ **conventional** rack-and-pinion electro-steering systems. For this purpose, in a simple ~~embodiment~~ **arrangement**, it ~~is also~~ **may be** possible to use only one sliding bearing 5 or generally one bearing for guiding the rack in the housing.

~~Abstract~~

ABSTRACT

A rack-and-pinion electro-steering system, ~~particularly~~ **e.g.,** for motor vehicles, has a rack extending in a housing, which is operatively connected to a thrust member/pinion pairing. At least one bearing between the rack and the housing is provided for guiding the rack. ~~According to the present invention, the~~ **The** bearing is ~~designed~~ **arranged** as a friction bearing. ~~This is because experiments have shown that a~~ **A** construction of the bearing between the rack and the housing as a sliding bearing ~~is~~ **may be particularly** suited ~~particularly well~~ for a reliable, durable and cost-effective guidance of the rack in the housing. In addition, for mounting the sliding bearings on the rack, a lock geometry is provided by which the sliding bearings may be locked after having been mounted on the rack. The lock geometry for example may be based on the lock geometry customary in sealing rings in automatic transmissions.

~~(Figure 1)~~

~~Reference numerals~~

REFERENCE NUMERALS

1	housing
1a	housing part (thrust member 4a)
1b	housing part (thrust member 4b)
1c	cylindrical housing part
2	rack
3a	pinion
3b	pinion
4a	thrust member
4b	thrust member
5	bearing, sliding bearing (rack housing)
6	sliding bearing, sliding bushing (thrust member housing part)